

## TECHNICAL NOTES

## Flavor and Physical Properties of Spray-dried Whole Milks with Bulk Densities .25, .4, and .6

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## ABSTRACT

Spray-dried whole milks foamed with nitrogen or conventionally spray-dried to bulk densities .25, .4, and .6 were compared regarding certain physical properties and flavor, initially and after oxygen free storage for 2, 4, and 6 mo at 4 C. Physical properties were in accord with previous results. No evidence was found for variations in flavor attributable to difference in bulk density. No flavor detectable oxidation was induced by oxygen "locked" inside the powder particles in dry whole milk of high bulk density.

## INTRODUCTION

Conventionally spray-dried whole milks with high bulk density can be easily reconstituted with an electric blender (7) and might be acceptable in a country like the United States where electric blenders are readily available. Low-heat, spray-dried beverage type whole milks require an expensive inert gas-oxygen scavenging type of packaging to eliminate oxidized flavor (4). Because of these considerations, substantial savings in packaging of high bulk density products which require smaller packages may be most important for success of this type of product in the United States. Conventionally spray-dried powder is much less porous than the foam spray-dried type (1). Gas transfer rates are low, and complete removal of oxygen from the powder's interior is slow. In foam spray-dried samples packed without a catalyst, oxygen in the headspace gas increased for a week to a maximum of about 1% (2). Removal of internal oxygen from conventionally spray-dried milk particles could take longer than from foam spray-dried milk. This conceivably could lead to oxidized flavor development during

storage in a dry whole milk with high bulk density because of oxygen "locked" inside the powder particles. Our purpose was to investigate this possibility.

Powders with bulk densities .25, .4, and .6 were prepared from the same batch of milk. Manufacturing procedures for the three types of powder were varied slightly to keep moisture levels close to the same. The products were packed in cans with an oxygen scavenging system consisting of 95% nitrogen, 5% hydrogen, and Pd catalyst (4). Flavor was evaluated by a 10-judge taste panel, initially and after 2, 4, and 6 mo of storage at 4 C. Certain physical properties are included in this report because they may be affected by different moisture levels. The moisture contents of the three products were closer together than reported previously (7).

## MATERIALS AND METHODS

Dry whole milks were prepared by procedures described previously (5). Milk was standardized to 3.3% fat and concentrated to 50% total solids (TS). Part of the concentrate was spray-dried, after addition of nitrogen for foaming, through a 1.02 mm diameter nozzle at 100 atm pressure into air at 132 C. Nitrogen was added at 130 atm pressure at 7 liters per kg of concentrate, producing a powder with a bulk density of about .25 g/ml. Another part of the concentrate, diluted with water to 42% TS, was spray-dried as above except at 127 C air temperature. Nitrogen for foaming was added just ahead of the high pressure pump at 3 atm pressure at a rate of .35 liters per kg of concentrate, producing a powder with a bulk density of about .4 g/ml. The third part of the concentrate, diluted with water to 40% TS, was spray-dried conventionally through a .77 mm diameter nozzle at 160 atm pressure into air at 121 C, producing a powder with a bulk density of over .6 g/ml. Sufficient powder was discarded between each collection to clear the drier of the preceding product. Samples for tasting were packed and held at 4 C for flavor

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TABLE 1. Composition and physical properties of spray-dried whole milks (DWM) with bulk densities (BD) .25, .4, and .6.<sup>a</sup>

Composition or physical property	DWM with BD .25		DWM with BD .4		DWM with BD .6	
	Range	Average	Range	Average	Range	Average
Moisture (%)	2.0 – 2.8	2.4	2.4 – 4.4	2.9	2.4 – 3.0	2.7
Fat (%)	25.9 – 27.1	26.5	26.2 – 27.2	26.6	25.7 – 27.3	26.7
BD loose (g/ml)	.16 – .20	.19	.26 – .29	.27	.34 – .37	.35
BD tamped (g/ml)	.24 – .25	.25	.38 – .45	.41	.62 – .63	.63
Dispersibility (%)	80 – 90	85	79 – 85	82	71 – 80	77
Disp. el. bl. <sup>b</sup>	97 – 102	100	100 – 103	101	100 – 103	102
Sinkability (%)	5 – 7	7	11 – 23	15	19 – 30	26
Solubility index (ml)	.1 – .2	.1	.2 – 1.0	.7	.7 – 2.1	1.6

<sup>a</sup>Calculated from data of four experiments.

<sup>b</sup>Percent dispersed in 1 min with an electric blender.

evaluations as described previously (4). Composition and physical properties were determined by procedures described previously (5, 7). The powders were judged as whole milks by a modified ADSA system (6).

#### RESULTS AND DISCUSSION

Composition and physical properties are listed in Table 1. Average moisture contents of the powders with .4 and .6 bulk density were .5 and .3% higher than that of the powder with .25 bulk density. Differences occurring in dif-

ferent experiments (range of values) were larger. Average bulk densities for the three types of products (.25, .41, and .63) were close to the projected values of .25, .4, and .6. Dispersibility decreased, and sinkability and solubility index increased with increasing bulk density while all products dispersed 100% in 1 min with an electric blender. This agrees with previous results (7). The solubility index of the powder with bulk density .6 and 26.7% fat was high (1.6), despite the low drier air temperature used (121 C), in contrast to the previous value .2 of a product with 13% fat (7).

TABLE 2. Comparative flavor scores and oxidized criticisms of spray-dried whole milks (DWM) with bulk densities (BD) .25, .4, and .6.<sup>a</sup>

Storage period at 4 C	DWM with BD .25		DWM with BD .4		DWM with BD .6	
	Range	Average	Range	Average	Range	Average
<i>Initially</i>						
Scores	36.3 – 36.9	36.5	36.3 – 37.0	36.6	36.3 – 37.0	36.7
Criticisms <sup>b</sup>	0		1		2	
<i>2 Months</i>						
Scores	35.2 – 35.5	35.3	35.1 – 35.5	35.2	35.1 – 35.9	35.4
Criticisms	0		5		5	
<i>4 Months</i>						
Scores	34.8 – 35.6	35.2	34.6 – 35.6	35.2	34.6 – 35.5	35.2
Criticisms	4		4		4	
<i>6 Months</i>						
Scores	34.7 – 35.7	35.1	34.8 – 35.4	35.0	35.0 – 35.7	35.2
Criticisms	2		3		1	

<sup>a</sup>Calculated from panel averages of four experiments.

<sup>b</sup>Number of "oxidized" criticisms, out of 80 judgments.

Data in Table 2 summarize the flavor evaluation of the dry milks. Each taste panel score is an average of 20 flavor evaluations (10 judges tasting duplicate samples). Averages and ranges in this table are derived from taste panel scores of four experiments and a total of 960 flavor evaluations.

Differences in flavor scores associated with replication are larger than those associated with different bulk densities. The latter appear to be so small as to be without practical significance. Oxidized flavor criticisms were slightly higher initially and after 2 mo of storage in powders with high bulk density. The difference disappeared after 4 and 6 mo of storage. This may indicate some effect on flavor resulting from slower rate of oxygen transfer in high bulk density powders. However, the effect, if real, was so slight that it did not show in the scores and, therefore, appeared to be without practical significance. The data were subjected to analysis of variance to test the hypothesis that the mean flavor scores of the three powders prepared with different bulk densities were equal. Total variance was partitioned into components due to bulk density and storage time. A summary of the analysis is in Table 3. The effect of bulk density was not significant. The effect of storage time was highly significant. Most of the flavor loss took place in the first 2 mo with a negligible effect due to storing an additional 2 to 4 mo. This is shown in Table 3 where the significant sum of squares for storage time is broken down into two components. The first reflects the difference between the initial average score and the 2, 4, and 6 mo scores, and is highly significant. The second represents a

residual, due possibly to other orthogonal contrasts, and is negligible. The effect of storage time is in accord with the fact that lactones formed during storage affect the flavor of dry whole milk. The low *F* of .45 is consistent with the hypothesis that the three types of powder have equal means.

No flavor-detectable oxidation was induced by oxygen "locked" inside the powder particles in dry whole milk with high bulk density.

The flavor scores 36.5 to 36.7 initially and 35.0 to 35.2 after 6 mo of storage (Table 2) were close to those of high quality fresh market milk and of milk with borderline acceptability which were scored 37 and 35, respectively, by the Dairy Products Laboratory taste panel. Dry whole milk protected from oxygen during storage loses fresh milk flavor because of lactone formation, its major flavor problem, which can be corrected by deodorizing the fat (3, 6).

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TABLE 3. Analysis of variance.

Source	Sum of squares	Degrees of freedom	F-values
Bulk density	.088	2	.45 <sup>a</sup>
Storage time	17.213	3	58.85 <sup>b</sup>
Initial versus 2, 4, 6 mo average	16.981	1	174.17 <sup>c</sup>
Residual	.232	2	
Error	4.095	42	
Total	21.396	47	

<sup>a</sup>F-value for significance at 5% = 3.23.

<sup>b</sup>F-value for significance at 1% = 4.31.

<sup>c</sup>F-value for significance at 1% = 7.31.

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